
Summary of "Factors Associated With Mortality in Adults Less Than Fifty-five Years Old Hospitalized for Community-Acquired Pneumonia"

By T.J. Marrie, K.C. Carrière, Y. Jin, D. Johnson

Purpose

Community-acquired pneumonia is both curable and responsive to appropriate therapy. Most studies about community-acquired pneumonia focus upon outcomes in seniors because of the high prevalence and mortality in this group. Young and middle age adults, however, have both a lower incidence and mortality for community-acquired pneumonia and risk factors associated with community-acquired pneumonia mortality in young and middle age adults have not been well described. Mortality from pneumonia in young and middle age adults may serve as a quality marker for the provision of timely health services for this curable disease.

Approach

Information from Alberta Health and Wellness hospital abstracts was used for Alberta patients between eighteen and fifty-five years of age during the period April 1, 1994 to March 31, 1999.

Key findings

The following are the key findings of this study:

- During the five years of the study, there were 11,684 hospitalizations for community-acquired pneumonia in young and middle age adults.
- The frequency of hospitalizations in eighteen to fifty-five year olds was dramatically less compared to older adults.
- In-hospital mortality during and after the first ten days of hospitalization was 2.1 percent and 3.2 percent, respectively.
- Seventy percent of those that died had one or more other disease with a cancer being the most common.
- Aspiration was the most important factor associated with mortality during the first ten days after hospital admission.
- Busy hospitals (higher occupancy, more daily admissions) were not associated with higher mortality.
- Bigger hospitals (metropolitan hospitals) had higher mortality but this was likely more related to sicker patients being treated.
- Most patients resided within fifty kilometres of the nearest hospital and a remote residence from a referral hospital was not associated with greater mortality. Only sixteen percent of deaths were within twenty-four hours of hospital admission so that adequate time for triage and referral were likely to have been present.

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Conclusions

Hospital discharges for community-acquired pneumonia and associated mortality were much lower in young and middle age adults compared to an older population. Aspiration was the most important clinical risk factor for mortality. Patients admitted with community-acquired pneumonia due to aspiration should raise the clinician's vigilance threshold for a poor outcome. Aspiration prevention may be a useful quality of care indicator for health organizations with the potential of decreasing mortality in young adults. These preventative strategies include careful use of sedatives, avoidance of recumbency in those with oral / nasal tube feeds, and good oral hygiene in bed-ridden patients.

Mortality from community-acquired pneumonia in young and middle aged adults is infrequent and is more related to the severity of the pneumonia and risk factors such as aspiration rather than the manner in which the provision of care is organized.

For more information

Copies of the report are available from the

Alberta Centre for Health Services Utilization Research

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- at http://www.health.gov.ab.ca/system/key/Research/achsur_reports.html

Alberta Centre for Health Services Utilization Research

The Alberta Centre for Health Services Utilization Research is a joint initiative between the University of Alberta and the University of Calgary, funded by Alberta Health and Wellness. The Centre conducts studies of how health services are used and delivered to inform health policy development and management of health services delivery.

Release date

January, 2003

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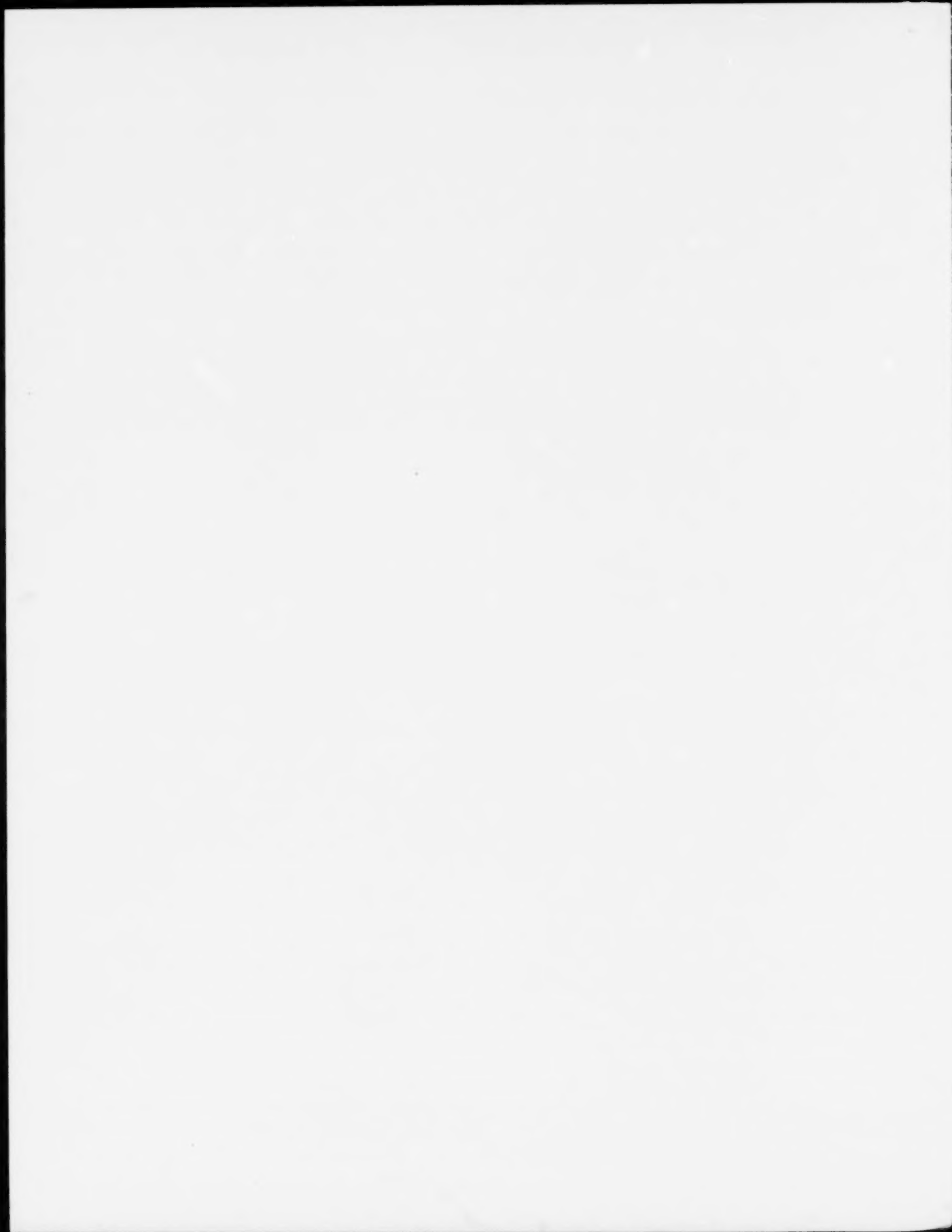
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January, 2003

Alberta Centre for Health Services Utilization Research



ACKNOWLEDGEMENT

The authors gratefully acknowledge the support provided by the Alberta Centre for Health Services Utilization Research, which conducts studies of how health services are used and delivered to inform health policy development and management of health service delivery. The Alberta Centre for Health Services Utilization Research is a joint initiative between the University of Alberta and the University of Calgary, funded by Alberta Health and Wellness. **The opinions and conclusions expressed in this paper are those of the authors and no endorsement by Alberta Health and Wellness is implied.**

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ISBN: 0-7785-2385-3

http://www.health.gov.ab.ca/system/key/Research/achsur_reports.html

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SUMMARY

Mortality from pneumonia in young and middle age adults may serve as a quality marker for the provision of timely health services for this curable disease. We used an administrative data base to study mortality in adults aged eighteen to fifty-five years who were hospitalized from April 1, 1994 to March 31, 1999 for treatment of community-acquired pneumonia. During the five years of the study there were 11,684 hospitalizations. First ten days and all in-hospital mortality rates were 2.1 percent and 3.2 percent respectively. Patient factors (age, sex and comorbidity) were the most important associations with mortality. Seventy percent of those that died had one or more comorbidities with malignancy being the most common. Aspiration was the most important association with mortality during the first ten days after hospital admission. The severity of pneumonia was greater in patients who aspirated. Busy hospitals (higher occupancy, more frequent daily admissions) were not associated with higher mortality. Bigger hospitals (metropolitan hospitals) had higher mortality but this was more likely related to greater comorbidity and severity of pneumonia. Admissions at times associated with fewer hospital staff (weekends / holidays evening and night) were not associated with higher mortality. Most patients resided within fifty kilometres of the nearest hospital and a remote residence from a referral hospital was not associated with greater mortality. Only sixteen percent of deaths were within twenty-four hours of hospital admission so that adequate time for triage and referral were likely to have been present.

We concluded that mortality from community-acquired pneumonia in young and middle-aged adults is infrequent and is more related to the severity of the pneumonia and risk factors such as aspiration rather than the manner in which the provision of care is organized. Aspiration prevention may be a useful quality of care indicator for health organizations with the potential of decreasing mortality in young adults. These preventative strategies might include careful use of sedatives, avoidance of recumbency in those with oral / nasal tube feeds, and good oral hygiene in bed-ridden patients.

INTRODUCTION

In-hospital mortality for community-acquired pneumonia is about fifteen percent which is related to its occurrence in those with serious chronic diseases and the elderly¹⁻⁸. Community-acquired pneumonia, unlike many other chronic diseases which are in themselves risk factors for pneumonia, is both curable and responsive to appropriate therapy⁹. Many community-acquired pneumonia studies focus upon outcomes in seniors because of the high prevalence and mortality in this group⁸⁻¹⁰. Young and middle age adults have both a lower incidence and mortality for community-acquired pneumonia¹³. Risk factors associated with community-acquired pneumonia mortality in young and middle age have not been well described. Mortality from pneumonia in young and middle age adults may serve as a quality marker for the provision of timely and appropriate health services for this curable disease.

In this study, we used administrative data to determine the rate and factors associated with in-hospital mortality for community-acquired pneumonia in young and middle age adults from April 1, 1994 to March 31, 1999. We assessed the relative associations of mortality with severity of pneumonia, co-existing comorbidity, and health care organizational factors.



METHODS

Defining Pneumonia and Data Extraction:

Two administrative health service databases were used and the analysis was done within the protected environment of Alberta Health and Wellness, governed by provincial legislative guidelines on the confidentiality of health information.

- Canadian Institute for Health Information's (CIHI) Inpatient Discharge Abstract Database (DAD) for the province of Alberta for 1994/95 to 1998/99,
- Alberta Health Insurance Plan Registry File for 1994 to 2000.

Community-acquired pneumonia was defined as the most responsible diagnosis (MRD) or any of the other fifteen diagnosis codes defined to be Type 1 (pre-admit comorbidity) with the ICD-9-CM values of 480.x to 487.x (pneumonia) or 507.x (aspiration pneumonia) excluding 484.x (pneumonia of infectious diseases classified elsewhere) ^{14, 15} found in CIHI DAD.

Exclusion Criteria:

- Not an Alberta resident or not treated in an Alberta acute care facility;
- Adjacent diagnosis related group (ADRG) defining hospitalization for a surgical procedure; and
- Any previous hospitalization within ten days of incident pneumonia case.

Risk Factors:

Demographic risk factors

- Ages 18 to 39 and 40 to 54 (age at the fiscal year-end is used);
- Sex;
- Year of admission;
- Urban or non-urban region of residence; and
- Export from home region (service region not in residence region).

Pneumonia etiologies (coded in any of the sixteen diagnosis variables)

- Aspiration (ICD-9-CM 507.x), and one of the following mutually exclusive sources of infection;
- Viral and influenza (ICD-9-CM 480.x, 487.x);
- Mycoplasma (ICD-9-CM 483.0);
- Pneumococcal pneumonia (ICD-9-CM 481.x);
- Other bacterial (ICD-9-CM 482.x excluding 482.9, 483.x excluding 483.0); and
- Unspecified source (ICD-9-CM 482.9, 485.x, 486.x).

Severity of Illness:

Severity of pneumonia is defined as any of the following which are coded in the sixteen diagnosis variables;

- Diagnosis code of respiratory failure or arrest (ICD-9-CM 518.81, 799.1),
- Diagnosis code of hypotension or shock (ICD-9-CM 458.xx, 785.5x),
- Mechanical ventilation for ninety-six or more hours (ICD-9-CM 96.72), and
- Special / intensive care unit admission (as defined by each hospital),

Charlson's comorbidities were extracted in any of the sixteen diagnosis variables using established definitions and each of twelve comorbidity types was summed as none, one, or more than one^{16, 17}. Malignancy was further classified as hematopoietic (ICD-9-CM 196, 200-208), metastatic solid tumor (ICD-9-CM 197-199.1) and other malignancy (ICD-9-CM 140-195.8). Alcohol-related problems (ICD-9-CM 291.x 303.x 305.x V11.3) were abstracted from any of the sixteen hospital abstract diagnosis fields.

Health Region Organization:**Hospital Factors**

1. Remote distance to local, regional, metropolitan hospital (see next page),
2. Transfer to hospital by ambulance as defined in hospital abstract,
3. Transfer from smaller to larger acute care facility for the diagnosis of pneumonia (see next page) as defined in the hospital abstract,
4. Admission from emergency room as defined in hospital abstract,
5. Hospital type (see next page),
6. Bed turnover defined as the ratio of all hospital admissions per hospital bed in the specific hospital on the date of pneumonia admission,
7. Occupancy rate defined as the daily census per hospital bed in the specific hospital at the date of pneumonia admission, and
8. Hospital beds per capita in health region.

All active hospital acute care beds in each year per resident region were surveyed and maintained in the provincial database.



Hospital Staff Factors

1. Any internal medicine specialist (coded in hospital abstract) listed as responsible physician,
2. Admission in December 1 to March 31 time period,
3. Admission time between 18:00 to 08:00, and
4. Weekend (Saturday / Sunday / statutory holiday) admission date

Derived Variables:

Calculating Remote Distance to Hospital

Each separation was mapped to the centre of a postal code and distances as the "crow flies" between centroids calculated. Nearest hospital (metropolitan, regional, and nearest) distance to resident postal code was obtained for all non-urban residents. Urban resident distances were zero. Distances greater than fifty kilometres were defined as remote.

Defining Hospital Type by Patient Volume:

Hospitals admitting patients with community-acquired pneumonia were categorized into five groups on the basis of the average number of hospital discharges per year over the five-year study period, geographic location, and medical school proximity:

Rural

Rural hospital were categorized by number of pneumonia cases (50 and 108 representing the 50th and 75th percentiles) into:

- Less than fifty cases per year comprising seventy-seven hospitals; and
- Fifty to one hundred and eight cases per year comprising twenty-seven hospitals.

Regional

Five regional hospitals were categorized for each of the five non-metropolitan regional health care cities ranging from 67 to 251 cases per year and one high volume rural hospital accounting for 221 cases per year was also added to this group.

Metropolitan

Seven metropolitan hospitals were located in the metropolitan health regions of Calgary and Capital hospitals ranging from 92 to 813 cases per year.



Two medical school metropolitan hospitals were located adjacent to medical schools with one hospital located in each of two metropolitan centres ranging from 493 and 610 cases per year.

Mortality:

Vital statistics declaration of death certificates were merged with the Alberta Health Care Premium Registry databank to determine de-registration from the plan. Reliability of linkage was high (99.5 percent) as verified by comparing in-hospital deaths recorded by hospital chart extraction to Alberta Health Care Premium Registry death derived from vital statistics.

Outcomes Used in Regressions Were:

1. In-hospital mortality per separation within the first ten days of admission, and
2. All in-hospital mortality.

STATISTICS

Age-specific (18 to 39, 40 to 54) hospital discharge, first twenty-eight-day mortality rates, and their ninety-nine percent confidence intervals were calculated using the 1998/99 provincial population. Age at the fiscal year-end is used for the rates. For illustrative purposes, age-specific hospital discharge and mortality rates for older patients (fifty-five and over) were also calculated.

A forward stepwise selection of factors was used to determine the order of importance of the factor influencing mortality. The factors were demographics, severity of illness, comorbidity, health region organization. Overall model prediction was expressed as a c-statistic. The c-statistic is a summary model statistic which equals the area under the receiver operator curve and is commonly reported for risk-adjustment models. C-statistics for in-hospital pneumonia mortality models have ranged between 0.67 to 0.85 where a value of 1 equals perfect prediction and 0.5 prediction no better than by chance¹⁸.

The unit of analysis was hospital discharge with some patients being hospitalized on multiple occasions per year. We attempted to adjust for correlations in hospital discharges within the same subject, but it did not result in substantial difference from those under the assumption of zero correlation. Therefore, we opted to report results of a simpler approach based on multiple logistic models¹⁹⁻²¹. The results were validated with the entire data to test for bias in the sample. Data was analyzed using the program SAS 8 [SAS Institute Inc. Cary, NC 2000] and significance was defined as $p < 0.05$.



RESULTS

During the five years of the study, there were 11,684 hospitalizations for community-acquired pneumonia in 10,466 patients between eighteen and fifty-five years old. The frequency of hospitalizations in eighteen to fifty-five year olds was dramatically less compared to older adults (Figure 1). The mortality in the first ten days after hospital admission was 2.1 percent and the overall in-hospital mortality was 3.2 percent. Out of 376 in-hospital deaths, 16.0 percent of the patients (n=60) died within twenty-four hours of admission, 18.6 percent (n=70) within twenty-five to seventy-two hours of admission, 63.0 percent (n=237) within seventy-three hours to two weeks of admission, and 2.4 percent (n=9) died beyond two weeks of admission. Again, mortality in the first twenty-eight days after hospital admission in eighteen to fifty-five year olds was dramatically less compared to older adults (Figure 2). As illustrated in Table 1, mortality was higher in males, those of urban residence, aspiration pneumonia cases, and cases with greater comorbidity (counts of one or more and in particular malignancy, vascular diseases, liver disease, and renal disease).

As illustrated in Table 2, mortality increased from 1.0 percent in rural hospitals, 2.6 percent in regional hospitals, and 5.8 percent in metropolitan hospitals. Mortality across hospital types mirrored mean patient comorbidity, with comorbidity counts increasing from 0.28 ± 0.57 in rural hospitals, 0.43 ± 0.71 in regional hospitals, and 0.58 ± 0.78 in metropolitan hospitals. The severity score for pneumonia (having any one of hypotension / shock, respiratory failure / arrest, special care unit admission, or mechanical ventilation) also increased from 0.03 ± 0.17 in rural hospitals, 0.18 ± 0.5 in regional hospitals, and 0.27 ± 0.68 in metropolitan hospitals. Mortality was lower in those patients with a residence that was remote from metropolitan, regional, or local hospital, although the number of patients remote from a local hospital was very low. The median daily hospital occupancy rate was seventy-five percent (interquartile range fifty-six percent to ninety percent). Other hospital staff risk factors were not associated with a dramatically different mortality. The median number of daily admission per bed was 0.15 (interquartile range 0.1 to 0.2). Patients that died were more likely to have an internal medicine specialist as the most responsible physician and were more likely to be admitted to a special care unit. Mortality was unrelated to seasonal variation in hospital admissions but was greater during weekend / holiday or evening / night admissions. Beds per capita were lower in metropolitan regions.

Table 3 illustrates the characteristics of aspiration pneumonia compared to non-aspiration pneumonia patients. Males were more likely to aspirate. In this younger aged cohort, cerebral vascular disease and hemiplegia were not commonly associated with community-acquired pneumonia. Comorbidity was similar in the aspiration and non-aspiration pneumonia patients except for alcohol-related problems which were greater in those who aspirated. Severity of pneumonia (presence of respiratory failure



or arrest, hypotension or shock, admission from emergency room, special / intensive care unit admission, mechanical ventilation) was higher in those with aspiration pneumonia.

Tables 4a and 4b show the regression results for mortality. The predictive characteristics of the model were good with a c-statistic and were comparable found in other models¹⁸. Aspiration provided the best predictive power for mortality within the first ten days of admission and was the third factor to enter the model for all in-hospital mortality. Other patient factors associated with mortality were comorbidity, age and sex. The only hospital staff variable that explained excess mortality was whether a specialist was listed as the most responsible physician. Metropolitan hospitals and regions with lower beds per capita were associated with increased mortality.

DISCUSSION

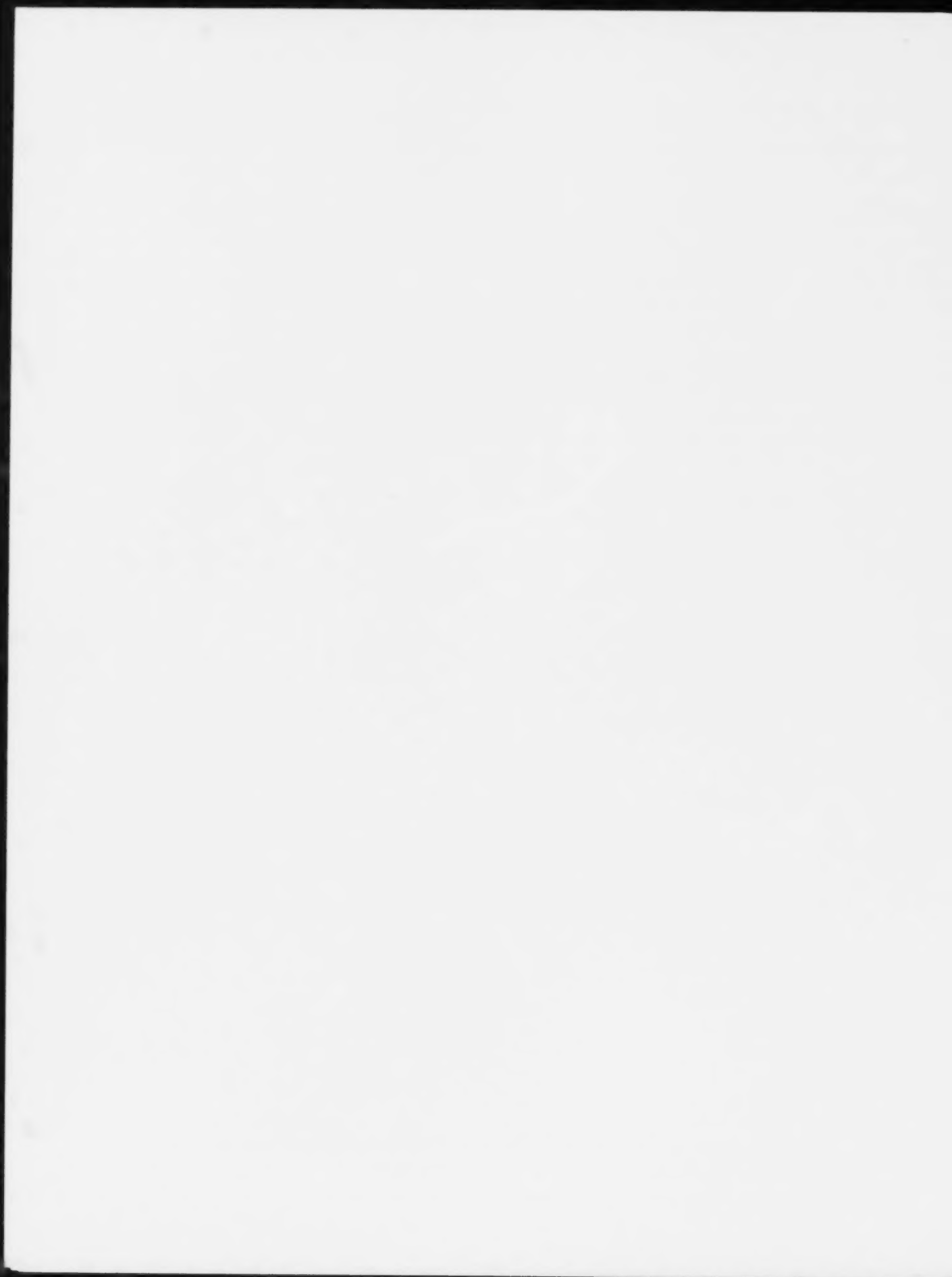
Hospital discharges for community-acquired pneumonia and associated mortality were much lower in young and middle age adults compared to an older population. Aspiration was the most important clinical risk factor for mortality. Patients admitted with community-acquired pneumonia related to aspiration should raise the clinician's vigilance threshold for the possibility of a poor outcome. Aspiration prevention may be a useful quality of care indicator for health organizations with the potential of decreasing mortality in young adults. Aside from aspiration, other patient factors (age, sex and comorbidity) had significant associations with mortality.

Most patients resided within fifty kilometres of the nearest hospital and a remote residence from a referral hospital was not associated with increased mortality. Only sixteen percent of deaths were within twenty-four hours of hospital admission so that adequate time for triage and referral were likely to have been present. However, transfer to a larger hospital was actually infrequent (1.5 percent of cases). Busy hospitals (higher occupancy, higher daily admissions) were not associated with higher mortality. Bigger hospitals (metropolitan hospitals) had higher mortality but this was likely more related to worse patient comorbidity and severity of pneumonia presentation. Admissions times at hospitals with fewer staff (weekends / holidays evening and night) were not associated with higher mortality. Internal medicine specialists were the most responsible physician in over seventy percent of deaths consistent with well established referral practices for these younger patients. About seventy percent of deaths occurred during the period of the third day to two weeks from admission and the associated factors for early deaths (first ten days) and all in-hospital deaths were similar. Mortality from community-acquired pneumonia in young and middle age adults was infrequent and was more related to the disease and patient factors rather than the manner in which the provision of care was organized.

Even in this younger patient group, older age (greater than forty) was still associated with higher mortality. Although the prevalence and severity of comorbidity increases with age, age and comorbidity are independent risk factors for mortality⁸. In this study, seventy percent of those that died had one or more comorbidity with malignancy being the most common. Etiological organism was not a predictor of mortality. Non-identified organisms accounted for sixty percent of cases in this study and was also noted in another study using administrative data²⁵. Aspiration has been associated with greater mortality in patients admitted from long term care. In long term care and hospital patients, oral gastric instrumentation, recumbency, oral hygiene, stroke, and decreased level of consciousness are associated with high rates of aspiration²²⁻²⁴. Strategies that limit aspiration for in-hospital patients have been shown to be useful^{22, 23}. Some of these strategies may be applicable for patients living in the community with similar risk factors. These preventative strategies include careful use of sedatives, avoidance of

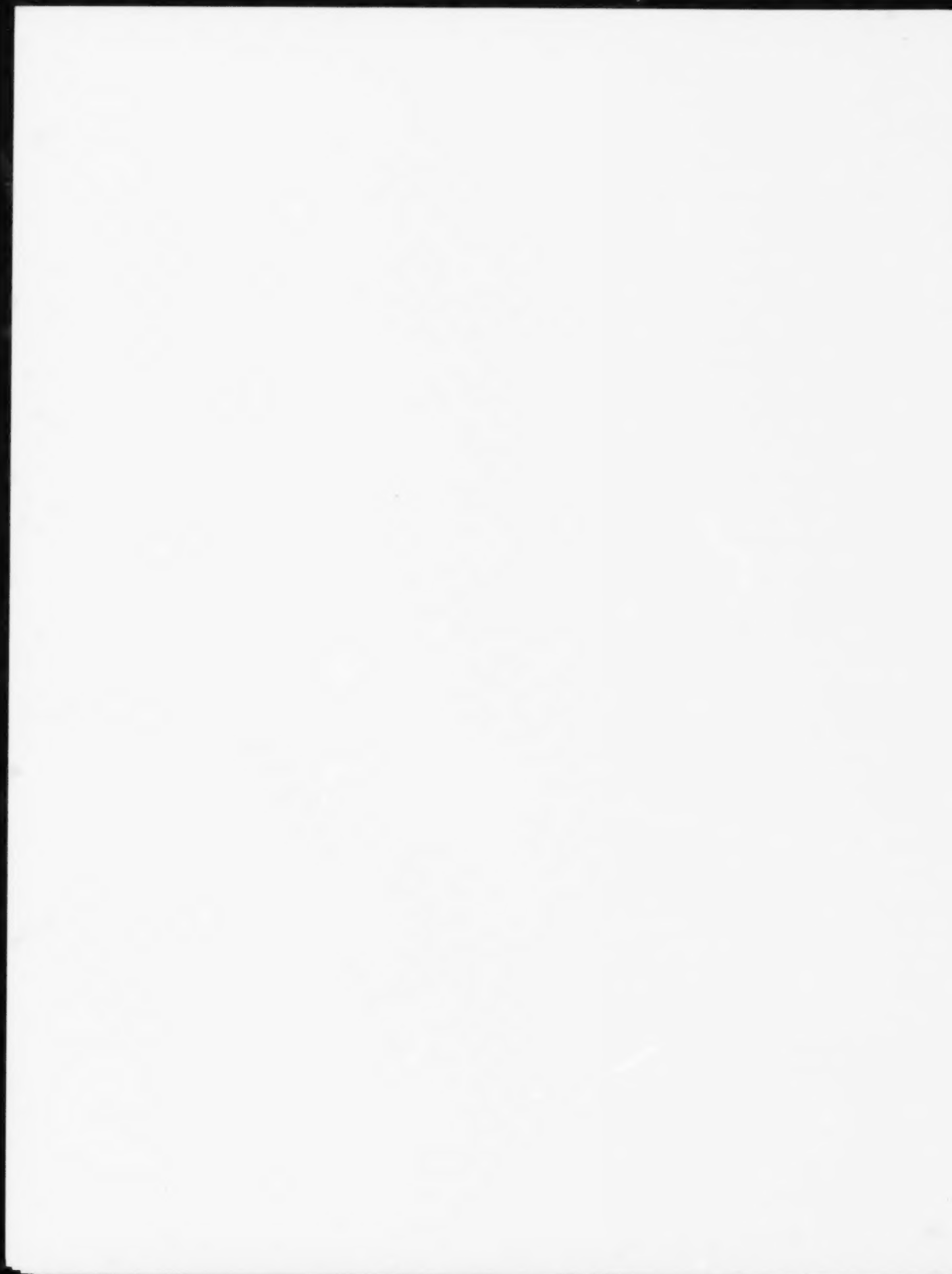
recumbency in those with oral / nasal tube feeds, and good oral hygiene in bed-ridden patients. Prevention (perhaps to specific alcohol-related problems) may have greater potential to improve outcomes compared to the process of care given that about forty percent are admitted to a special care unit and about seventy-seven percent had an internal medicine specialist as the most responsible physician.

Our study has several limitations. Population-based administrative database research is highly generalizable although limited in clinical details. We attempted to adjust for case severity (hypotension / shock, respiratory arrest / failure) and case mix (comorbidity, age, and sex) but may not have captured all variation²⁶. These variables are likely less reliable than a clinically derived pneumonia index². Processes of care variables such as use of a special / intensive care unit or transfer to another hospital are not justified by a specific threshold in severity of illness or special care provided. As such, these variables would be expected to vary widely between patients and hospitals.

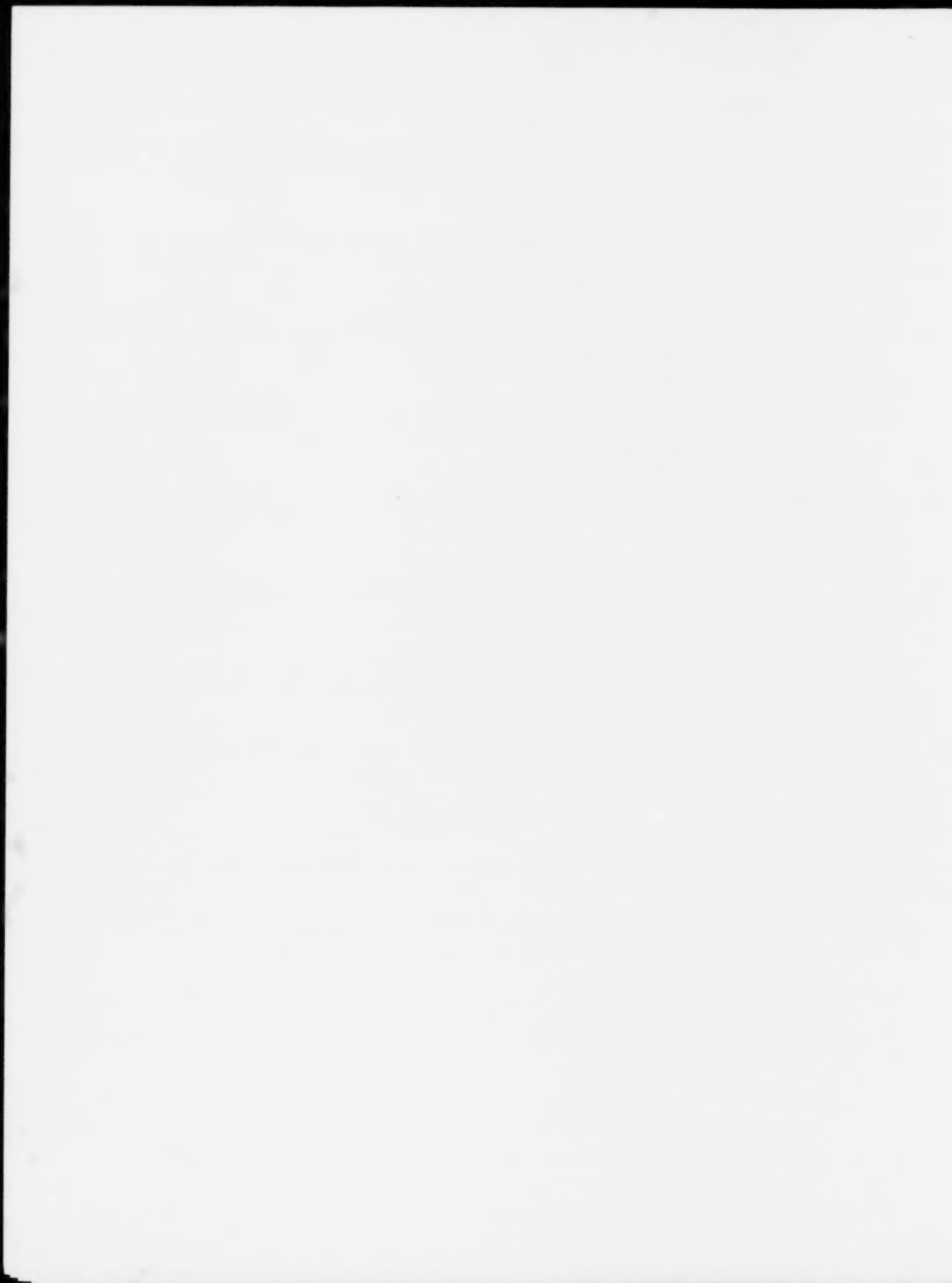


REFERENCES

1. Feagan, B.G., Marrie, T.J., Lau, C.Y., Wheeler, S.L., Wong, C.J., and Vandervoort, M.K., Treatment and Outcomes of Community-acquired Pneumonia at Canadian Hospitals, *CMAJ*, 2000; 162: 1,415-20
2. Marrie, T.J., Lau, C.Y., Wheeler, S.L., Wong, C.J., Vandervoort, M.K., and Feagan, B.G., A Controlled Trial of a Critical Pathway for Treatment of Community-acquired Pneumonia, *JAMA*, 2000; 283: 749-55
3. Fine, M., Hough, L., Medsger, A., Li, Y.H., Ricci, E., Singer, D., Marrie, T.J., Coley, C.M., Walsh, M.B., Karpf, M., Lahive, K.C., and Kapoor, W.N., The Hospital Admission Decision for Patients with Community-acquired Pneumonia, *Arch Intern Med*, 1997; 157: 36-44
4. Bartlett, J.G. and Mundy, L.M., Community-acquired Pneumonia, *New England Journal of Medicine*, 1995; 333: 1,618-24
5. Metersky, M.L., Galusha, D.H., and Meehan, T.P., Improving the Care of Patients With Community-acquired Pneumonia, *The Joint Commission on Accreditation of Healthcare Organization Journal*, 1999; 25: 182-190
6. Neiderman, M.S., McCombs, J., Unger, A., Kumar, A., and Popovian, R., The Cost of Treating Community-acquired Pneumonia, *Clin Ther*, 1998; 20: 820-36
7. Fine, J.M., Smith, M.A., Carson, C.A., Mutha, S.S., Sankey, S.S., Weissfeld, L.A., and Kapoor, W.N., Prognosis and Outcomes of Patients With Community-acquired Pneumonia, *JAMA*, 1996; 275: 134-141
8. Fine, M.J., Orloff, J.J., Arisumi, D., Fang, G.D., Arena, V.C., Hanusa, B.H., Yu, V.L., Singer, D.E., and Kapoor, W.N., Prognosis of Patients Hospitalized With Community-acquired Pneumonia, *American Journal of Medicine*, 1990; 88: 1N-8N
9. Gleason, P.P., Meehan, T.P., Fine, J.M., Galusha, D.H., and Fine, M.J., Associations Between Initial Antimicrobial Therapy and Medical Outcomes for Hospitalized Elderly Patients With Pneumonia, *Archives of Internal Medicine*, 1999; 159: 2,562-72
10. Koivula, I., Sten, M., and Makela, P.H., Prognosis After Community-acquired Pneumonia in the Elderly : A Population-based 12 Year Follow-up Study, *Archives of Internal Medicine*, 1999; 159: 1,550-5



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11. Marrie, T.J., Haldane, E.V., Faulkner, R.S., Durant, H., and Kwan, C., Community-acquired Pneumonia Requiring Hospitalization: Is it Different in the Elderly? *J Am Geriatr Soc*, 1985; 33: 671-80
 12. Venkatesan, P., Gladman, J., Macfarlane, J.T., Barer, D., Berman, P., Kinnear, W., and Finch, R.G., A Hospital Study of Community-acquired Pneumonia in the Elderly, *Thorax*, 1990; 45: 254-8
 13. Ely, E.W. and Haponik, E.F., Pneumonia in the Elderly, *Journal of Thoracic Imaging*, 1991; 6: 45-61
 14. Draper, D., Kahn, K.L., Reinisch, E.J., Sherwood, M.J., Carney, M.F., Kosecoff, J., Keeler, E.B., Rogers, W.H., Savitt, H., Allen, H., Wells, K.B., Reboussin, D., and Brook, R.H., Studying the Effects of the DRG-based Prospective Payment System on Quality of Care, *JAMA*, 1990; 264: 1,956-1,961
 15. Marrie, T.J., Durant, H., and Sealy, E., Pneumonia – The Quality of Medical Records, *Medical Care*, 1987; 25: 20-24
 16. Deyo, R.A., Cherkin, D.C., and Ciol, M.A., Adapting a Clinical Comorbidity Index for use With ICD-9-CM Administrative Databases, *Journal of Clinical Epidemiology*, 1992; 45: 613-9
 17. Romano, P.S., Roos, L.L., and Jollis, J.G., Adapting a Clinical Comorbidity Index for use With ICD-9-CM Administrative Data: Differing Perspectives, *Journal of Clinical Epidemiology*, 1993; 46: 1,075-9
 18. Iezzoni, L.I., (1998), *Risk Adjustment for Measuring Healthcare Outcomes*, Second edition, Health Administration Press, Chicago, Illinois, p 432-43
 19. Seber, (1977), *Linear Regression Analysis*, Wiley, New York
 20. Hosmer, D.W. and Lemeshow, S., (1989), *Applied Logistic Regression*, John Wiley and Sons, New York, U.S.A.
 21. Cree, M., Roos, N., Yang, Q., and Carriere, K.C., Hypertensive Patients and Their General Practitioners, *Healthcare Management Forum*, 2001; 14: 33-40
 22. Vergis, E.N., Brennen, C., Wagener, M., and Muder, R.R., Pneumonia in Long-term Care: A Prospective Case-control Study of Risk Factors and Impact on Survival, *Archives of Internal Medicine*, 2001; 161: 2,378-81



-
23. Pick, N., McDonald, A., Bennett, N., Litsche, M., Dietsche, L., Legerwood, R., Spurgas, R., and LaForce, F.M., Pulmonary Aspiration in a Long-term Care Setting: Clinical and Laboratory Observations and an Analysis of Risk Factors, *Journal of the American Geriatrics Society*, 1996; 44: 763-8
 24. Marik, P.E., Aspiration Pneumonitis and Aspiration Pneumonia, *New England Journal of Medicine*, 2001; 344: 665-671
 25. Garcia-Ordenez, M.A., Garcia-Jimenez, J.M., Paez, F., Alvarez, F., Poyato, B., Franquelo, M., Colmenero, J.D., and Juarez, C., Clinical Aspects and Prognostic Factors in Elderly Patients Hospitalized for Community-acquired Pneumonia, *European Journal of Clinical Microbiology and Infectious Diseases*, 2001; 20: 14-9
 26. Ewig, S., Ruiz, M., Mensa, J., Marcos, M.A., Martinez, J.A., Arancibia, F., Niederman, M.S., and Torres, A., Severe Community-acquired Pneumonia, Assessment of Severity Criteria *American Journal of Respiratory and Critical Care Medicine*, 1998; 158: 1,102-8

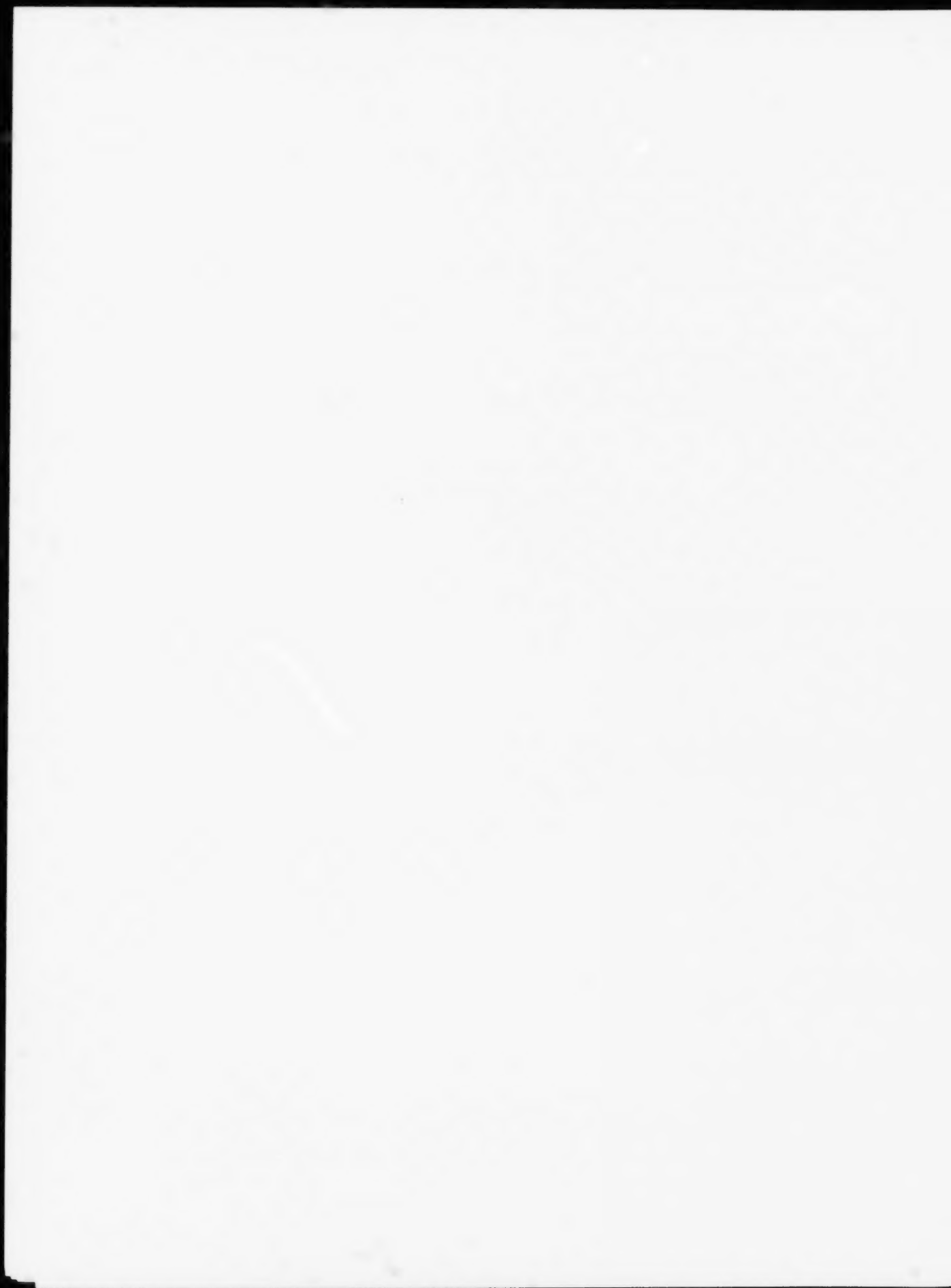


Table 1 – Patient demographic and comorbidity risk factors for community-acquired pneumonia in Alberta during April 1, 1994 to March 31, 1999

	All pneumonia hospital discharges (N and %)	First ten-day in-hospital mortality (N and %)	All in-hospital mortality (N and %)
All Cases	11,684	249	376
Patient Characteristics			
Female	6,034 (51.6%)	93 (37.3%)	152 (40.4%)
Male	5,640 (48.4%)	156 (62.7%)	224 (59.6%)
Mean age (standard deviation)	37.9 (10.1)	42.5 (9.7)	42.6 (9.5)
Urban region of residence	4,414 (37.8%)	160 (64.3%)	237 (63.0%)
Pneumonia Etiology			
Aspiration	835 (7.1%)	82 (32.9%)	108 (28.7%)
Viral and influenza	1,894 (16.2%)	0 (0.0%)	2 (0.5%)
Mycoplasma	291 (2.5%)	0 (0.0%)	0 (0.0%)
Pneumococcal pneumonia	1,012 (8.7%)	21 (8.4%)	32 (8.5%)
Other bacterial	723 (6.25%)	15 (6.0%)	35 (9.3%)
Unspecified bacteria	7,021 (60.1%)	138 (55.4%)	212 (56.4%)
Pneumonia Severity			
Respiratory failure or arrest	354 (3.0%)	67 (26.9%)	98 (26.1%)
Hypotension or shock	187 (1.6%)	56 (22.5%)	67 (17.8%)
Special / intensive care unit admission (as defined by each hospital)	954 (8.2%)	117 (47.0%)	162 (43.1%)
Mechanical ventilation	214 (1.8%)	31 (12.4%)	66 (17.6%)
Comorbidity			
Comorbidity (one or more)	3,752 (32.1%)	171 (68.7%)	276 (73.4%)
Chronic obstructive pulmonary disease	2,012 (17.2%)	26 (10.4%)	37 (9.8%)
Diabetes without end organ damage	590 (5.0%)	22 (8.8%)	29 (7.7%)
Diabetes with end organ damage	127 (1.1%)	3 (1.2%)	9 (2.4%)
Malignancy or metastatic solid tumor (combined)	501 (4.3%)	77 (30.9%)	129 (34.3%)
Hematopoietic malignancy	206 (1.8%)	23 (9.2%)	41 (10.9%)
Metastatic solid tumor	222 (1.9%)	51 (20.5%)	81 (21.5%)
Other malignancy	272 (2.3%)	50 (20.1%)	82 (21.8%)
Congestive heart failure	312 (2.7%)	13 (5.2%)	24 (6.4%)
Vascular (acute myocardial infarction, peripheral vascular disease, cerebral vascular disease, hemiplegia) combined	323 (2.8%)	30 (12.0%)	52 (13.8%)
Acute myocardial infarction,	163 (1.4%)	13 (5.2%)	18 (4.8%)
Peripheral vascular disease,	20 (0.2%)	3 (1.2%)	4 (1.1%)
Cerebral vascular disease, hemiplegia	152 (1.3%)	19 (7.6%)	36 (9.6%)
Dementia	3 (0.0%)	0 (0.0%)	0 (0.0%)
Liver disease (mild determined by ICD-CM code)	110 (0.9%)	18 (7.2%)	29 (7.7%)
Liver disease (moderate to severe determined by ICD-CM code)	94 (0.8%)	17 (6.8%)	31 (8.2%)
Renal disease (moderate to severe determined by ICD-CM code)	141 (1.2%)	16 (6.4%)	28 (7.4%)
Rheumatologic disease	172 (1.5%)	5 (2.0%)	8 (2.1%)
Peptic ulcer disease	132 (1.1%)	5 (2.0%)	9 (2.4%)

Note that percentages reflect the numbers of cases in which data was available for each variable.

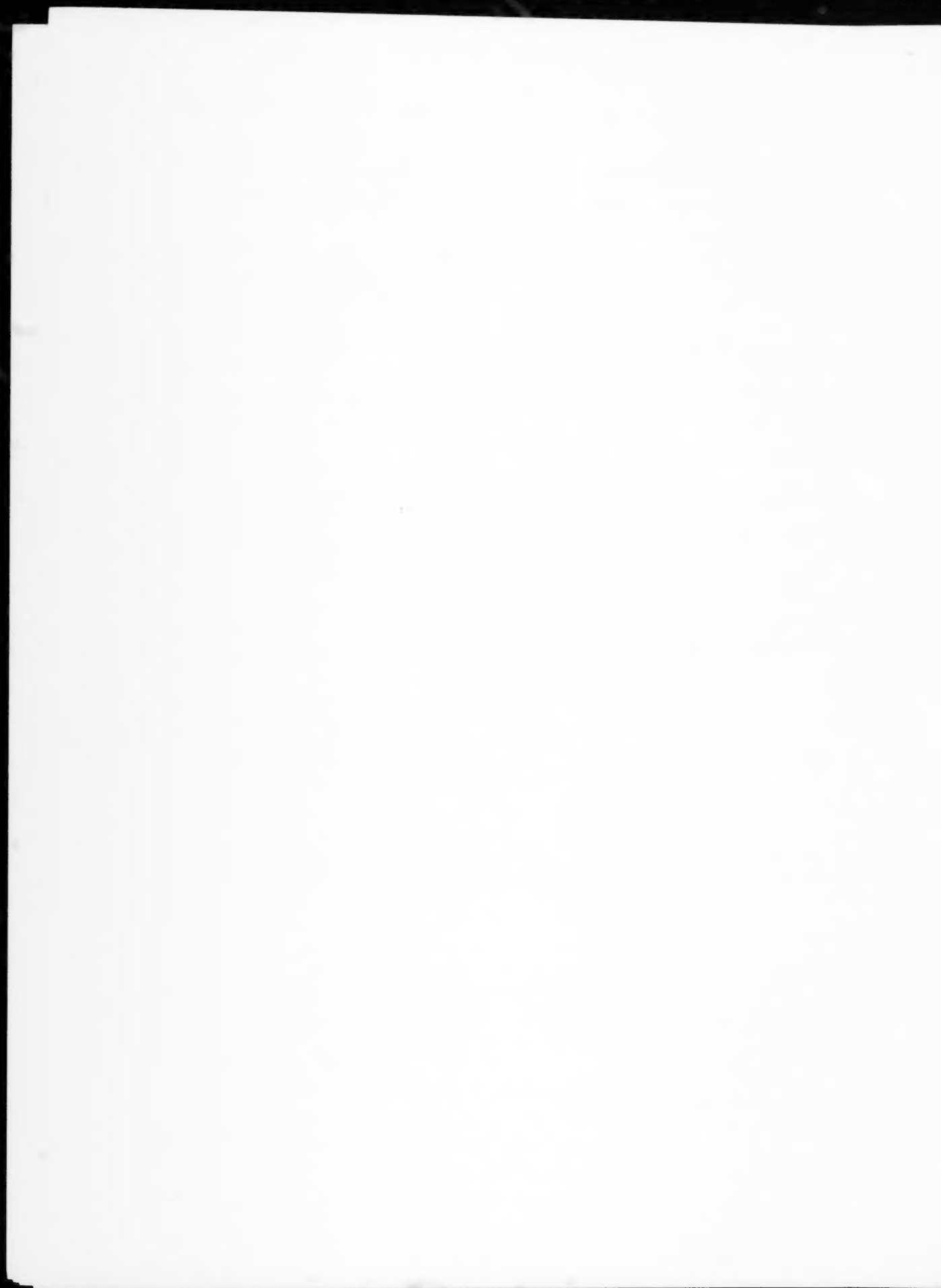


Table 2 – Health region organizational risk factors for community-acquired pneumonia in Alberta during April 1, 1994 to March 31, 1999

	All pneumonia hospital discharges (N and %)	First ten-day in-hospital mortality (N and %)	All in-hospital mortality (N and %)
All Cases	11,684	249	376
Hospital Factors			
Remote distance from metropolitan hospital	6,433 (55.9%)	62 (25.8%)	102 (27.9%)
Remote distance from regional hospital	4,903 (42.6%)	34 (14.2%)	59 (16.1%)
Remote distance from nearest hospital	175 (1.5%)	0 (0.0%)	0 (0.0%)
Rural hospital (less than fifty cases per year)	2,694 (23.1%)	21 (8.4%)	30 (8.0%)
Rural hospital (fifty to one hundred and eight cases per year)	2,501 (21.4%)	12 (4.8%)	23 (6.1%)
Regional hospital	1,713 (14.7%)	28 (11.2%)	44 (11.7%)
Urban hospital (metropolitan)	3,188 (27.3%)	119 (47.8%)	169 (44.9%)
Urban hospital (metropolitan in proximity to a medical school)	1,588 (13.6%)	69 (27.7%)	110 (29.3%)
Transfer to a larger acute hospital	150 (1.3%)	N/A	N/A
Admission from emergency room	3,489 (29.9%)	77 (30.9%)	117 (31.1%)
Beds per 1,000 greater than median of 2.32 in 1998/99	5,958 (51.3%)	66 (27.3%)	101 (27.6%)
Hospital Staff Factors			
Any internal medicine specialist listed as consultant	4,591 (39.3%)	176 (70.7%)	277 (73.7%)
Admission in December 1 to March 31 time period	4,739 (40.6%)	81 (32.5%)	128 (34.0%)
Admission time between 8:00 to 15:59	5,115 (43.8%)	91 (36.5%)	149 (39.6%)
Admission time between 16:00 to 23:59	4,836 (41.4%)	99 (39.8%)	149 (39.6%)
Admission time between 24:00 to 07:59	1,733 (14.8%)	59 (23.7%)	78 (20.7%)
Weekend / holiday admission date	3,154 (27.0%)	85 (34.1%)	123 (32.7%)
Annual occupancy rate greater than ninety percent	3,952 (34.2%)	96 (39.2%)	144 (39.0%)
Daily admissions per bed greater than median of 0.15	6,686 (57.9%)	110 (44.9%)	176 (47.7%)

Note that percentages reflect the number of cases in which data was available for each variable.

NA – not available.



Table 3 – Comparison of patients (number and percent) with and without aspiration as the etiology for community-acquired pneumonia in Alberta during April 1, 1994 to March 31, 1999

	Hospital discharges with aspiration N=835	Hospital discharges without aspiration N=10,849
Mean age (std)	39.2 (10.0)	37.8 (10.1)
Female	307 (36.8%)	5,727 (52.8%)
One or more comorbidity	257 (30.8%)	3,495 (32.2%)
Alcohol related problems	279 (33.4%)	1,480 (13.6%)
Any malignancy	33 (4.0%)	468 (4.3%)
Cerebral vascular disease, hemiplegia	34 (4.1%)	118 (1.1%)
Respiratory failure or arrest	100 (12.0%)	254 (2.3%)
Hypotension or shock	53 (6.3%)	134 (1.2%)
Special / intensive care unit admission	351 (42.0%)	603 (5.6%)
Mechanical ventilation	86 (10.3%)	128 (1.2%)
Severity of pneumonia ¹	569 (68.1%)	3,704 (34.1%)
Admission from emergency room	311 (37.2%)	3,178 (29.3%)
Any internal medicine specialist listed as most responsible physician	641 (76.8%)	3,950 (36.4%)

¹ Where severity of pneumonia is any one of respiratory failure or arrest, hypotension or shock, mechanical ventilation, or special / intensive care unit admission

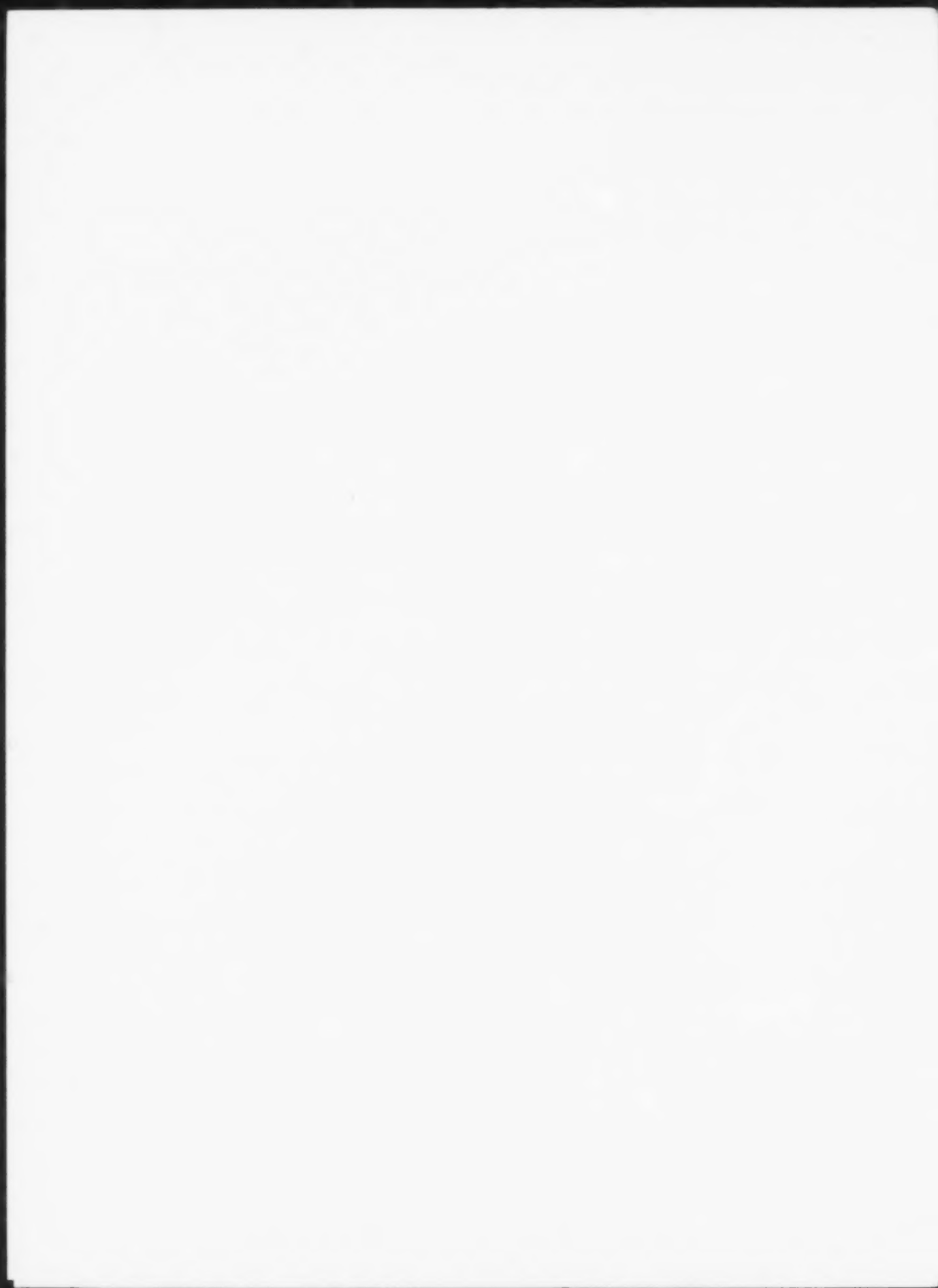


Table 4a – Mortality logistic regression for hospital death within the first ten days of hospital admission

Factor group	Factor	Odds ratio (95% CI)
Patient – severity	Aspiration	5.0 (3.7-6.75)
Patient – comorbidity	Comorbidity n=1 ¹	2.9 (2.1-3.9)
Patient – comorbidity	Comorbidity n= 2 ¹	6.9 (4.9-9.7)
Patient – comorbidity	Age group (forty or more) ²	1.9 (1.4-2.5)
Patient – comorbidity	Sex-female ³	0.64 (0.49-0.83)
Health care organization factor	Beds per 1,000 greater than median of 2.32 in 1998/99	0.68 (0.51-0.89)
Health care organization factor	Admission to rural hospital ³ (50 to 108 cases per year)	0.60 (0.29-1.2)
Health care organization factor	Admission to regional hospital ⁴	1.46 (0.82-2.6)
Health care organization factor	Admission to urban hospital ⁴ (metropolitan)	2.7 (1.7-4.3)
Health care organization factor	Admission to urban hospital ⁴ (metropolitan in proximity to a medical school)	2.1 (1.3-3.6)

¹ reference group is no comorbidity.

² reference group is age group (18-39 years).

³ reference group is males, and

⁴ reference group is admission to rural hospital with less than fifty cases per year

Note that the order of factors indicate the relative strength of the explanatory power. The c-statistic for the model is 0.85.

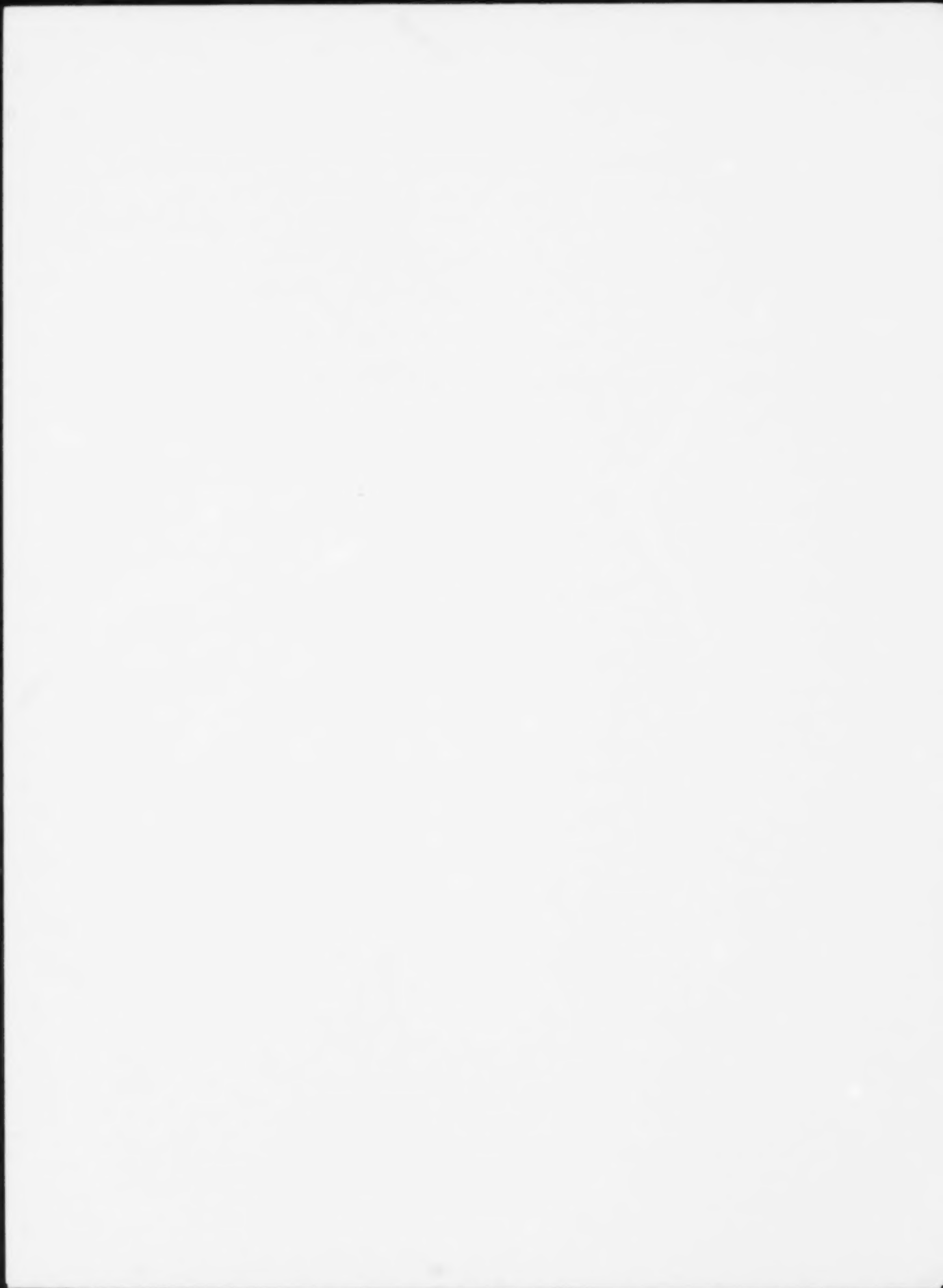


Table 4b – Mortality regression for all in-hospital deaths

Factor group	Factor	Odds ratio (95% CI)
Patient – comorbidity	Comorbidity n=1 ¹	3.2 (2.5-4.2)
Patient – comorbidity	Comorbidity n= 2 ¹	10.6 (7.9-14.2)
Patient – severity	Aspiration	4.4 (3.3- 5.7)
Health care organization factor	Internal medicine specialist as the most responsible physician ²	1.4 (1.1- 1.9)
Patient – comorbidity	Age group (forty or more) ³	1.8 (1.4- 2.3)
Patient – comorbidity	Sex-female ⁴	0.70 (0.56-0.88)
Health care organization factor	Beds per 1,000 persons greater than median of 2.32 in 1998/99	0.74 (0.59-0.94)
Health care organization factor	Admission to rural hospital ⁵ (50 to 108 cases per year)	0.82(0.47- 1.43)
Health care organization factor	Admission to regional hospital ⁵	1.4 (0.82- 2.2)
Health care organization factor	Admission to urban hospital ⁵ (metropolitan)	2.2 (1.4 – 3.4)
Health care organization factor	Admission to urban hospital ⁵ (metropolitan in proximity to a medical school)	2.0 (1.2 – 3.3)

¹ reference group is no comorbidity.

² reference group is no specialist listed.

³ reference group is age group (18-39 years).

⁴ reference group is males, and

⁵ reference group is admission to rural hospital with less than 50 cases per year.

Note that the order of factors indicate the relative strength of the explanatory power. The c-statistic for the model is 0.85

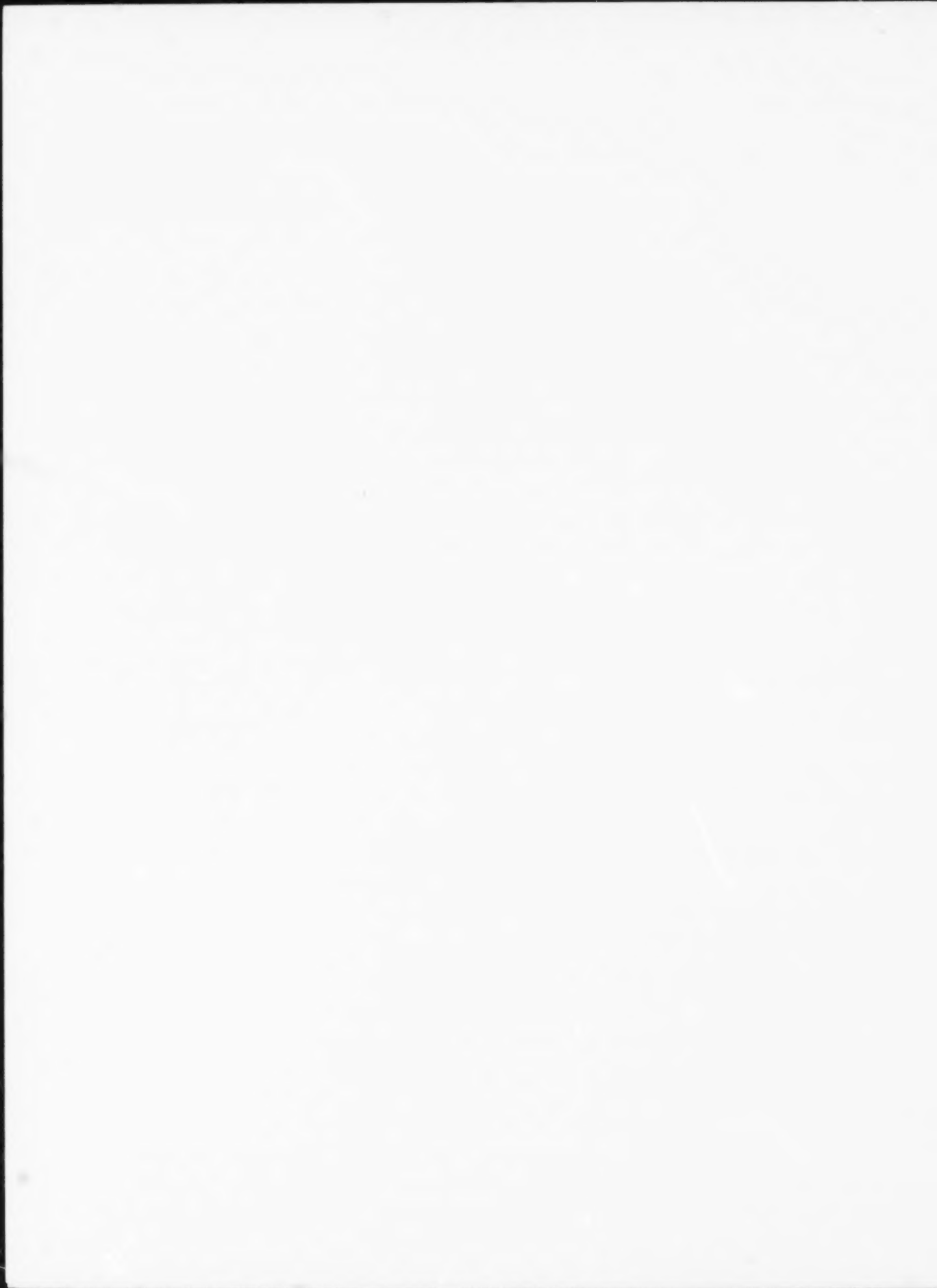


FIGURE LEGEND

Figure 1

Age-specific hospitalization rate (ninety-nine percent confidence intervals) for community-acquired pneumonia in Alberta during April 1, 1994 to March 31, 1999. Note that all rates are significantly different but the absolute magnitude of those fifty-five years and older is seven-fold greater.

Figure 2

Age-specific in-hospital mortality during the first twenty-eight days of hospital stay for community-acquired pneumonia in Alberta during April 1, 1994 to March 31, 1999. Note that all rates are significantly different but the absolute magnitude of those fifty-five years and over is greater.

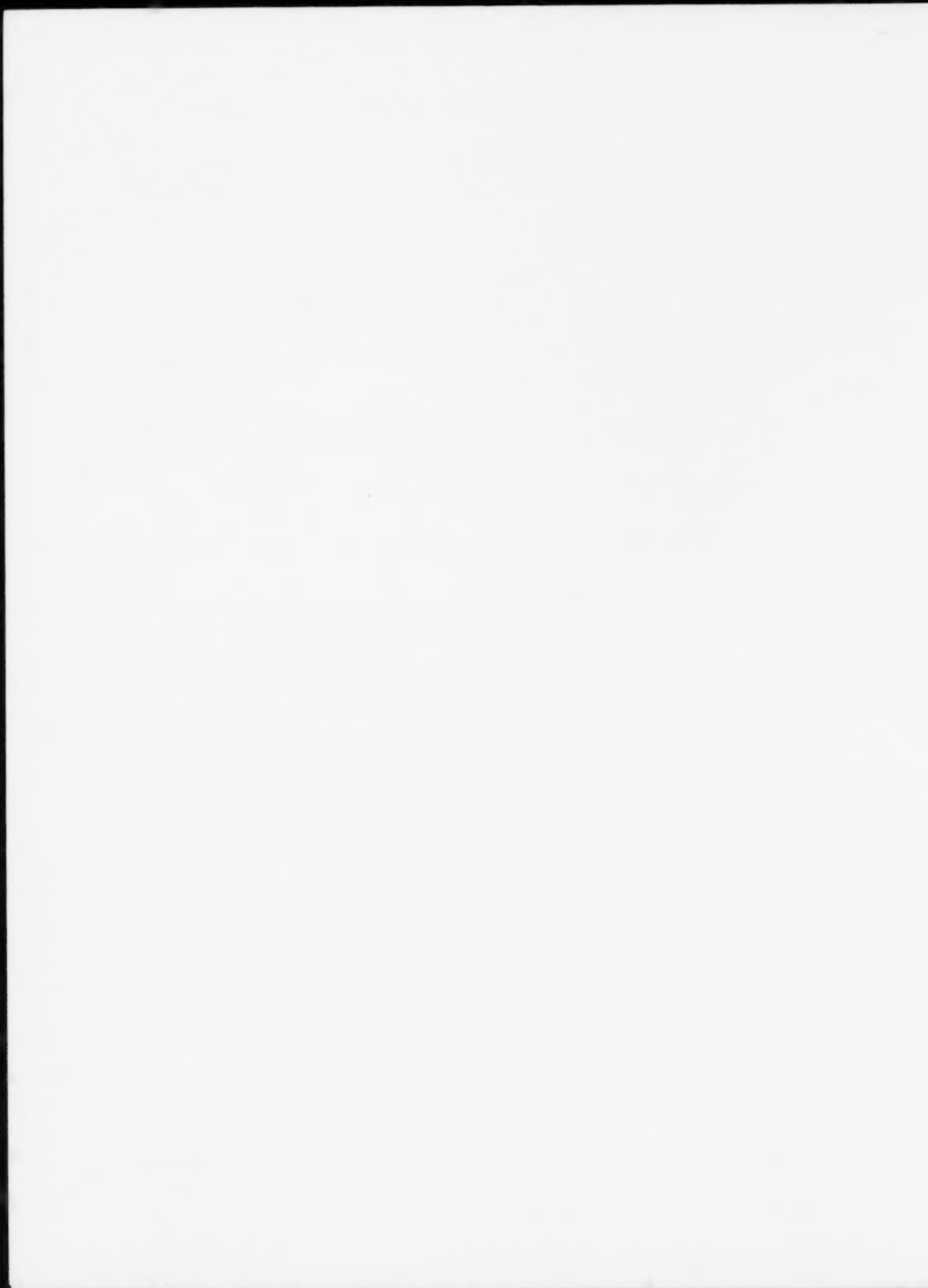


Figure 1 – Hospitalization for Community-Acquired Pneumonia

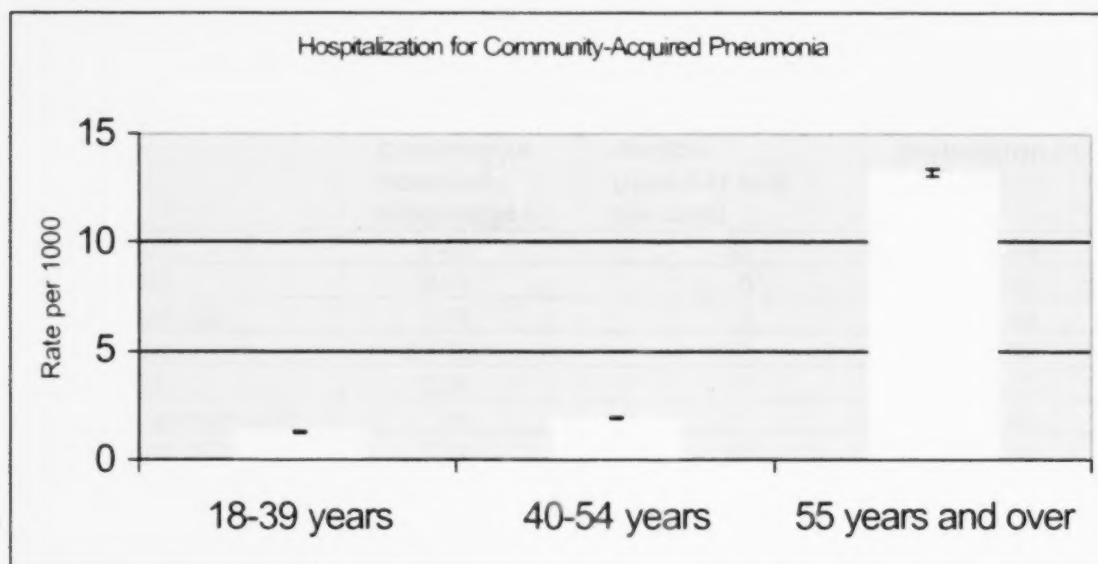
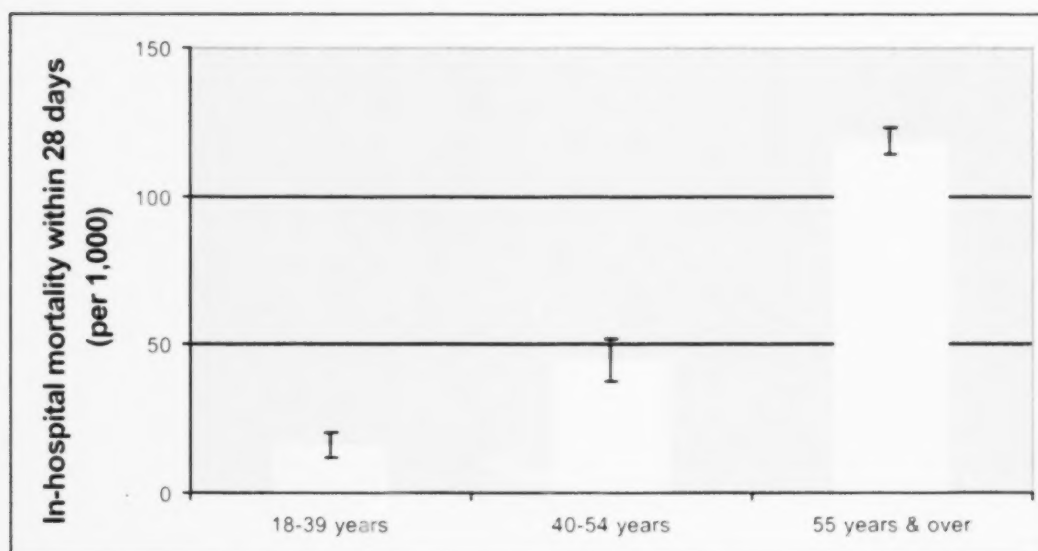
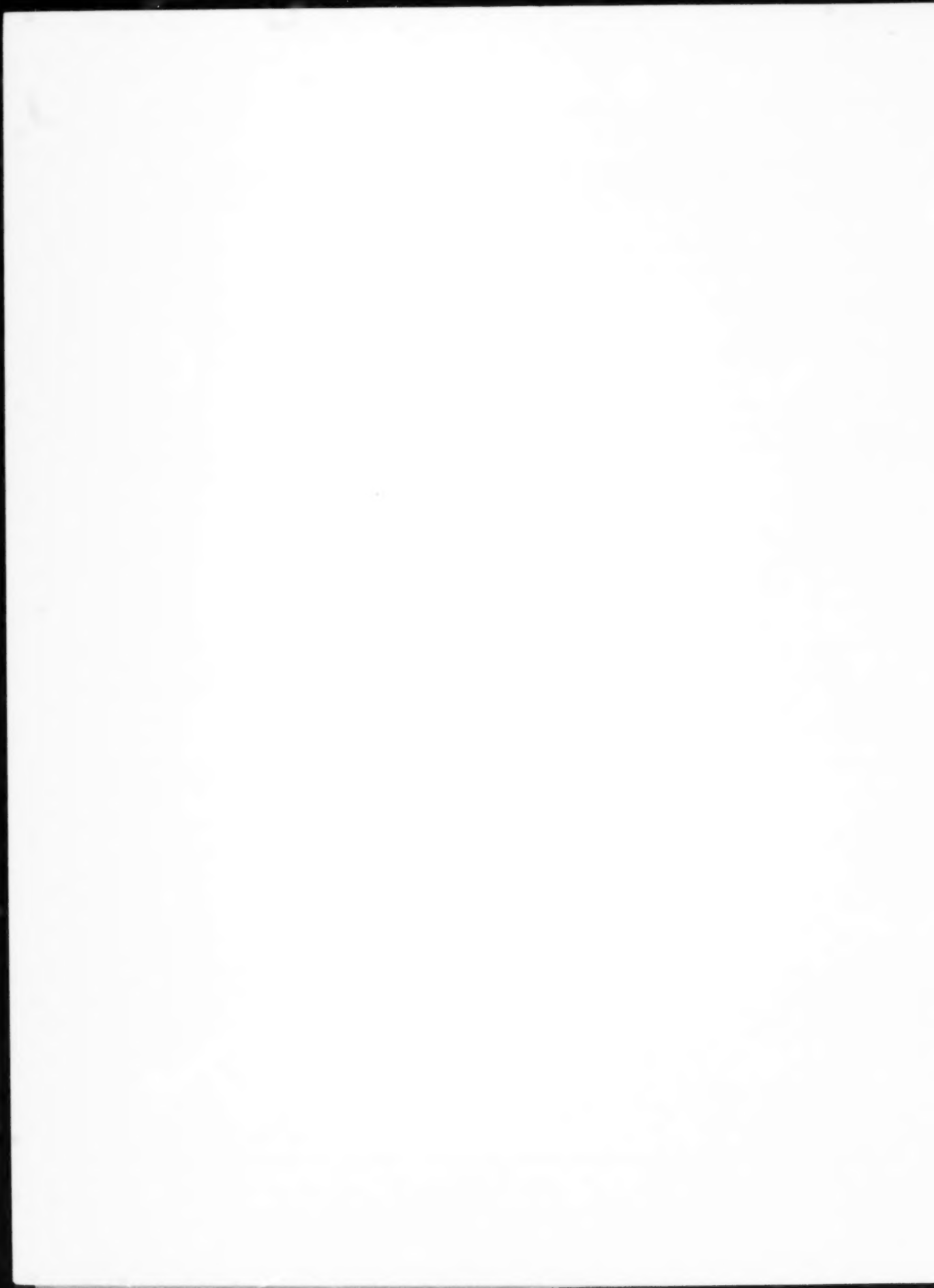


Figure 2 – In-Hospital Mortality Within Twenty-Eight Days



APPENDIX**Appendix A – Beds per capita for community-acquired pneumonia in Alberta during April 1, 1994 to March 31, 1999**

Health region name	Number of pneumonia hospital discharges	All in-hospital deaths (number and percent)	Beds per 1,000 population in 1998/99
Chinook (01)	743	22	2.54
Palliser (02)	441	6	2.90
Headwaters (03)	376	8	1.34
Calgary (04)	2,108	112	1.98
RHA 5 (05)	324	11	2.25
David Thompson (06)	1,185	21	2.44
East Central (07)	731	13	2.35
Westview (08)	356	11	0.65
Crossroads (09)	416	8	3.14
Capital (10)	2,306	125	2.06
Aspen (11)	575	9	2.22
Lakeland (12)	742	14	2.21
Mistahia (13)	489	8	2.99
Peace (14)	174	2	3.01
Keeweenaw Lakes (15)	392	2	2.32
Northern Lights (16)	176	4	2.09
Northwestern (17)	150	0	2.35



BIOGRAPHIES

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Dr. Marrie's major research interest is in the area of community-acquired pneumonia. Over the years this focus has evolved from laboratory based research to a population health basis. Dr. Marrie's interest is in understanding the variation that occurs in the treatment of pneumonia and finding ways to minimize this variation.

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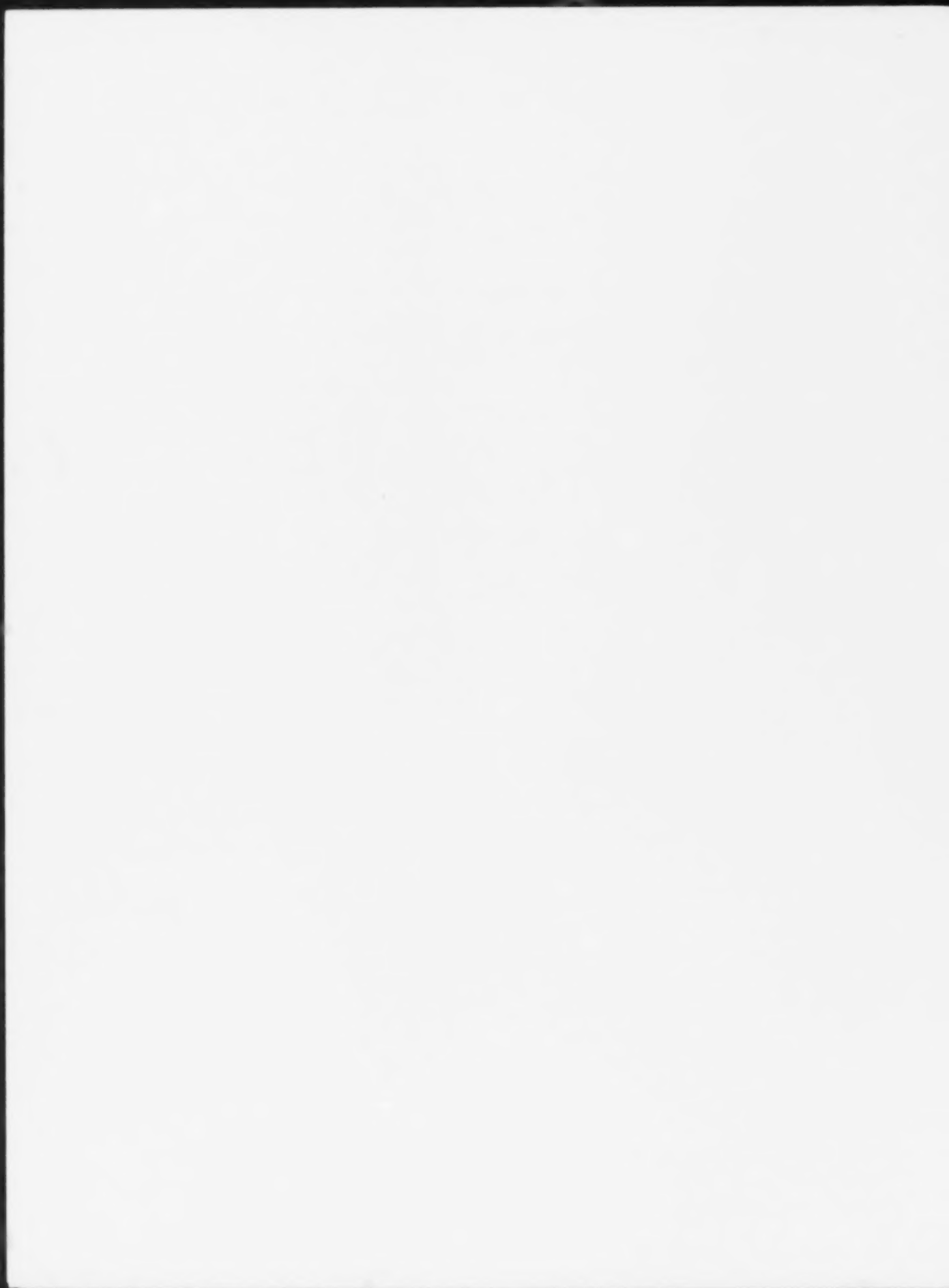
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As a physician, Dr. David Johnson's clinical practice is affected by the health care system. Dr. Johnson is interested in understanding and promoting the use of information in directing health policy formation and decision-making by the managers of the health care system.

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